

## PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING  
OF A CHANGE(PCT Rule 92bis.1 and  
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

HARRISON GODDARD FOOTE  
Tower House  
Merrion Way  
Leeds LS2 8PA  
ROYAUME-UNI

Date of mailing (day/month/year) 03 July 2000 (03.07.00)	<b>IMPORTANT NOTIFICATION</b>
Applicant's or agent's file reference CTV/P45136WO	
International application No. PCT/GB00/00519	International filing date (day/month/year) 17 February 2000 (17.02.00)

## 1. The following indications appeared on record concerning:

☐ the applicant
                 
 ☐ the inventor
                 
 ☒ the agent
                 
 ☐ the common representative

Name and Address HARRISON GODDARD FOOTE Belmont House 20 Wood Lane Leeds LS6 2AE United Kingdom	State of Nationality	State of Residence
	Telephone No. 44-113-225-8350	
	Facsimile No. 44-113-230-4702	
	Teleprinter No.	

## 2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person
                 
 ☐ the name
                 
 ☒ the address
                 
 ☐ the nationality
                 
 ☐ the residence

Name and Address HARRISON GODDARD FOOTE Tower House Merrion Way Leeds LS2 8PA United Kingdom	State of Nationality	State of Residence
	Telephone No. 44-113-290-1400	
	Facsimile No. 44-113-244-2829	
	Teleprinter No.	

## 3. Further observations, if necessary:

## 4. A copy of this notification has been sent to:

<input checked="" type="checkbox"/> the receiving Office	<input type="checkbox"/> the designated Offices concerned
<input checked="" type="checkbox"/> the International Searching Authority	<input type="checkbox"/> the elected Offices concerned
<input type="checkbox"/> the International Preliminary Examining Authority	<input type="checkbox"/> other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Beatriz Morariu Telephone No.: (41-22) 338.83.38
---	---

## PCT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents  
United States Patent and Trademark  
Office  
Box PCT  
Washington, D.C.20231  
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year)  
12 October 2000 (12.10.00)

International application No.  
PCT/GB00/00519

Applicant's or agent's file reference  
CTV/P45136WO

International filing date (day/month/year)  
17 February 2000 (17.02.00)

Priority date (day/month/year)  
17 February 1999 (17.02.99)

## Applicant

RAMSHAW, Colin et al

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:  
15 September 2000 (15.09.00)

☐ in a notice effecting later election filed with the International Bureau on:  
\_\_\_\_\_

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland

Authorized officer

Juan Cruz

Facsimile No.: (41-22) 740.14.35

Telephone No.: (41-22) 338.83.38

## PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING  
OF A CHANGE(PCT Rule 92bis.1 and  
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

HARRISON GODDARD FOOTE  
Tower House  
Merrion Way  
Leeds LS2 8PA  
ROYAUME-UNI

Date of mailing (day/month/year) 04 December 2000 (04.12.00)	<b>IMPORTANT NOTIFICATION</b>
Applicant's or agent's file reference CTV/P45136WO	
International application No. PCT/GB00/00519	International filing date (day/month/year) 17 February 2000 (17.02.00)

## 1. The following indications appeared on record concerning:

☒ the applicant
                 
 ☐ the inventor
                 
 ☐ the agent
                 
 ☐ the common representative

Name and Address UNIVERSITY OF NEWCASTLE 6 Kensington Terrace Newcastle Upon Tyne NE1 7RU United Kingdom	State of Nationality GB	State of Residence GB
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

## 2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person
                 
 ☒ the name
                 
 ☒ the address
                 
 ☐ the nationality
                 
 ☐ the residence

Name and Address NEWCASTLE UNIVERSITY VENTURES LIMITED Sun Alliance House 35 Mosley Street Newcastle upon Tyne NE1 1XX United Kingdom	State of Nationality GB	State of Residence GB
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

## 3. Further observations, if necessary:

## 4. A copy of this notification has been sent to:

<input checked="" type="checkbox"/> the receiving Office	<input type="checkbox"/> the designated Offices concerned
<input type="checkbox"/> the International Searching Authority	<input checked="" type="checkbox"/> the elected Offices concerned
<input checked="" type="checkbox"/> the International Preliminary Examining Authority	<input type="checkbox"/> other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Mougamadou ABIDINE Telephone No.: (41-22) 338.83.38
---	--

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

HARRISON GODDARD FOOTE  
Tower House  
Memion Way  
Leeds LS2 8PA  
GRANDE BRETAGNE

PCT

2

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT  
(PCT Rule 71.1)

10.MAY2001\*054126

Date of mailing  
(day/month/year)

08.05.2001

Applicant's or agent's file reference  
CTV/P45136WO

IMPORTANT NOTIFICATION

International application No.  
PCT/GB00/00519

International filing date (day/month/year)  
17/02/2000

Priority date (day/month/year)  
17/02/1999

Applicant

NEWCASTLE UNIVERSITY VENTURES LTD. et al

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/

European Patent Office  
D-80298 Munich  
Tel. +49 89 2399 - 0 Tlx 523656 epmu d  
Fax +49 89 2399 - 4465

Authorized officer

Gregoire, J-P


Tel. +49 89 2399-8041

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>CTV/P45136WO</b>		<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. <b>PCT/GB00/00519</b>	International filing date (day/month/year) <b>17/02/2000</b>	Priority date (day/month/year) <b>17/02/1999</b>	
International Patent Classification (IPC) or national classification and IPC <b>B01J19/18</b>			
<b>10.MAY2001-054127</b>			
Applicant <b>NEWCASTLE UNIVERSITY VENTURES LTD. et al</b>			
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 4 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 807 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 4 sheets.</p>			
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li>I <input checked="" type="checkbox"/> Basis of the report</li> <li>II <input type="checkbox"/> Priority</li> <li>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li>IV <input type="checkbox"/> Lack of unity of invention</li> <li>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li>VI <input type="checkbox"/> Certain documents cited</li> <li>VII <input type="checkbox"/> Certain defects in the international application</li> <li>VIII <input type="checkbox"/> Certain observations on the international application</li> </ul>			
Date of submission of the demand <b>15/09/2000</b>		Date of completion of this report <b>08.05.2001</b>	
Name and mailing address of the international preliminary examining authority:  <b>European Patent Office</b> <b>D-80298 Munich</b> <b>Tel. +49 89 2399 - 0 Tlx 523856 epmu d</b> <b>Fax: +49 89 2399 - 4465</b>		Authorized officer  <b>Buesing, G</b>  Telephone No. +49 89 2399 8356	

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00519

**I. Basis of the report**

1. With regard to the elements of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17):*)

**Description, pages:**

1,4-31	as originally filed		
2,3	as received on	16/03/2001	with letter of 16/03/2001

**Claims, No.:**

1-16	as received on	16/03/2001	with letter of 16/03/2001
------	----------------	------------	---------------------------

**Drawings, sheets:**

1/12-12/12	as originally filed
------------	---------------------

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00519

- ☐ the description, pages:  
☐ the claims, Nos.:  
☐ the drawings, sheets:
5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):  
*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Yes:	Claims 1 - 16
	No:	Claims
Inventive step (IS)	Yes:	Claims
	No:	Claims 1 - 16
Industrial applicability (IA)	Yes:	Claims 1 - 16
	No:	Claims

**2. Citations and explanations**  
**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/00519

**Section V:**

1. The invention relates to reactor apparatus with a rotatable support element to which feed means are associated. In order to improve mixing or the residence time of the reactants, means are provided on the surface of the support element. Such means can be a mesh (claim 1), pins or wires (claim 2) or a layer of a reticulate foam (claim 3).
2. The closest prior art document is US-A-4 549 998 which also discloses a reactor apparatus with a rotatable support element to which feed means are associated. In order to improve the mass transfer between reactants, means are provided on the surface of the support element which can be protrusions from the surface (column 1, lines 55-57), the provision of a foraminated, cribriform or gauze-like porous plate (column 2, lines 9-18).
3. Claims 1 and 3 are novel over US-A-4 549 998 because they require the mesh or foam, respectively, to be provided as a layer on the surface whereas the structure according to US-A-4 549 998 does not have a separate surface. Claim 2 is also novel because the pins or wires mentioned therein are not unambiguously disclosed in US-A-4 549 998 which more generally refers to protrusions from the surface.
4. However, it appears that this does not result in a significant functional difference. The problems underlying the invention and US-A-4 549 998 are basically the same, and the solutions suggested in US-A-4 549 998 would guide the ordinarily skilled worker to the subject-matter defined in any of the independent claims 1, 2 or 3 by routine work, according to the circumstances, and he would obtain the claimed reactors without the exercise of an inventive skill. Consequently, the claimed reactors lack an inventive step.

It is not apparent that the features defined in the dependent claims contribute to an inventive step. It rather appears that they also are the result of routine work which the ordinarily skilled worker would carry out.



These publications therefore disclose the use of spinning disc technology for heating and mass transfer in inert and reactive systems.

5 GB 9903474.6 (University of Newcastle), from which the present application claims priority and the disclosure of which is hereby incorporated into the present application by reference, describes the use of RSORT in the conversion of a fluid phase substrate by dynamic heterogeneous contact with an agent. In this application, it is described how it has surprisingly been found that spinning disc technology may be further adapted to apply process intensification methods not only within the fields of heat and mass transfer but also within the field of heterogeneous contacting. Furthermore, it is described how it has surprisingly been found that the quality of the product obtained is of higher quality than that obtained by conventional processing having, for example, a higher purity or, in polymers, a narrower molecular distribution.

15 In addition to this, spinning disc technology can be used to obtain products not readily obtainable by other technology.

20 According to a first aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is provided with at least one layer of a mesh which enhances its effective surface contact area in relation to the reactant and which increases a residence time of the reactant on the surface when the reactor apparatus is in use.

30 According to a second aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is provided with pins or wires which enhance its effective surface contact area in relation to the reactant and which increase a residence time of the reactant on the surface when the reactor apparatus is in use.

35 According to a third aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is provided with at least one layer of a reticulate foam which enhances its effective surface contact area in relation to the reactant and which increases a residence time of the reactant on the surface when the reactor apparatus is in use.

40 In some embodiments of the present invention, the surface is also provided with a catalytic material.

5 The catalytic material may be applied as a smooth layer or may be roughened so as to provide enhanced surface area. Preferably, the catalytic material is a heterogeneous catalyst. Examples of such catalysts include platinum, palladium, nickel or any of these metals supported on or impregnated in a layer of alumina (for hydrogenation of liquids), or chromia (for polyolefin production).

10 The surface may be treated by ion bombardment or implantation so as to produce changes in surface wettability.

15 It is to be understood that the term "reactant" is not limited to substances which are intended to undergo chemical reaction on the surface of the support element, but also includes substances which are intended to undergo physical or other processes such as mixing or heating. Similarly, the term "product" is intended to denote the substance or substances which are collected from the first surface of the support element, whether these have undergone chemical or physical processing or both. In addition, although it is envisaged that most reactants and products will be in the liquid phase, the apparatus can be used with any suitable fluid phase reactants and products, including combinations of liquid, solid and gaseous reactants and products.

20 For example, solid phase substances in substantially free-flowing particulate form can have macroscopic fluid flow properties.

25 Reference herein to a rotating surface is to any continuous or discrete planar or three dimensional surface or assembly which rotates approximately or truly about an axis, and preferably is reference to an approximate or true rotating surface of revolution. An approximate rotating surface of revolution may comprise an asymmetric axis and/or deviation in the surface body and/or circumference creating an axially or radially undulating surface of revolution. A discrete surface may be in the form of a mesh, grid, corrugated surface and the like.

30 Reference herein to a substantially radially outward flowing film as hereinbefore defined is to any fluid film which may be created by dynamic contact of the fluid phase reactant and the rotating surface as hereinbefore defined, suitably the fluid phase reactant is contacted with the rotating surface at any one or more surface

35 locations and caused to flow outwardly by the action of centrifugal force. A film may be a continuous annulus or may be a non-continuous arc at any radial location. The substrate may provide a plurality of films in dynamic contact with a rotating surface as hereinbefore defined.

40 For example processes requiring extended contact time may be carried out in continuous manner with use of a recycle of fluid exiting at the periphery of the

**CLAIMS:**

1. A reactor apparatus including a support element (3) adapted to be rotatable about an axis (6), the support element (3) having a surface (5) and feed means (4) associated therewith for supplying at least one reactant (15) to the surface (5), characterised in that the surface (5) is provided with at least one layer of a mesh (60) which enhances its effective surface contact area in relation to the reactant (15) and which increases a residence time of the reactant (15) on the surface (5) when the reactor apparatus is in use.
2. A reactor apparatus including a support element (3) adapted to be rotatable about an axis (6), the support element (3) having a surface (5) and feed means (4) associated therewith for supplying at least one reactant (15) to the surface (5), characterised in that the surface (5) is provided with pins or wires which enhance its effective surface contact area in relation to the reactant (15) and which increase a residence time of the reactant (15) on the surface (5) when the reactor apparatus is in use.
3. A reactor apparatus including a support element (3) adapted to be rotatable about an axis (6), the support element (3) having a surface (5) and feed means (4) associated therewith for supplying at least one reactant (15) to the surface (5), characterised in that the surface (5) is provided with at least one layer of a reticulate foam which enhances its effective surface contact area in relation to the reactant (15) and which increases a residence time of the reactant (15) on the surface (5) when the reactor apparatus is in use.
4. A reactor as claimed in claim 1, wherein the surface (5) is provided with two or more layers of a mesh (60).
5. A reactor as claimed in claim 1 or 4, wherein the layer or layers of mesh (60) are such that there is good thermal conduction between the mesh (60) and the surface (5).
6. A reactor as claimed in any one of claims 1, 4 or 5, wherein the mesh (60) is made of metal.
7. A reactor as claimed in any one of claims 1 or 4 to 6, wherein the mesh (60)

has a thickness of the same order of magnitude as a thickness of a film (17) of reactant (15) which is formed on the surface (5) when the reactor is in operation.

- 5 8. A reactor as claimed in any one of claims 1 or 4 to 7, wherein the mesh (60) is made out of or coated with a catalytic material.
9. A reactor as claimed in any preceding claim, wherein the surface (5) is porous.
- 10 10. A reactor as claimed in any preceding claim, wherein the surface (5) is provided with a catalytic material.
11. A reactor as claimed in claim 10, wherein a plate of catalytic material is clamped, welded or otherwise adhered to the surface (5).
- 15 12. A reactor as claimed in any preceding claim, wherein the surface (5) is treated by ion bombardment or implantation so as to produce changes in surface wettability.
13. A reactor as claimed in any preceding claim, wherein the axis (6) is substantially parallel to a direction of action of terrestrial gravity.
- 20 14. A reactor as claimed in any one of claims 1 to 12, wherein the axis (6) is inclined with respect to a direction of action of terrestrial gravity.
- 25 15. A reactor as claimed in any one of claims 1 to 12, wherein the axis (6) is substantially perpendicular to a direction of action of terrestrial gravity.
- 30 16. A reactor as claimed in any preceding claim, wherein there is further provided a rotary impeller or fan (70) mounted close to the surface (5) and operable to generate a gaseous flow from a periphery of the surface (5) towards a central region thereof, this flow being counter-current to a flow of reactant (15) on the surface (5).

REC'D 10 MAY 2001

WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)



14

Applicant's or agent's file reference CTV/P45136WO		<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB00/00519	International filing date (day/month/year) 17/02/2000	Priority date (day/month/year) 17/02/1999
International Patent Classification (IPC) or national classification and IPC B01J19/18		
Applicant NEWCASTLE UNIVERSITY VENTURES LTD. et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
  - ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:
  - I ☒ Basis of the report
  - II ☐ Priority
  - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
  - IV ☐ Lack of unity of invention
  - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
  - VI ☐ Certain documents cited
  - VII ☐ Certain defects in the international application
  - VIII ☐ Certain observations on the international application

Date of submission of the demand 15/09/2000	Date of completion of this report 08.05.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Buesing, G Telephone No. +49 89 2399 8356 

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00519

**I. Basis of the report**

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

**Description, pages:**

1,4-31	as originally filed		
2,3	as received on	16/03/2001	with letter of 16/03/2001

**Claims, No.:**

1-16	as received on	16/03/2001	with letter of 16/03/2001
------	----------------	------------	---------------------------

**Drawings, sheets:**

1/12-12/12	as originally filed
------------	---------------------

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00519

- ☐ the description,      pages:  
☐ the claims,      Nos.:  
☐ the drawings,      sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes:	Claims	1 - 16
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1 - 16
Industrial applicability (IA)	Yes:	Claims	1 - 16
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

**Section V:**

1. The invention relates to reactor apparatus with a rotatable support element to which feed means are associated. In order to improve mixing or the residence time of the reactants, means are provided on the surface of the support element. Such means can be a mesh (claim 1), pins or wires (claim 2) or a layer of a reticulate foam (claim 3).
2. The closest prior art document is US-A-4 549 998 which also discloses a reactor apparatus with a rotatable support element to which feed means are associated. In order to improve the mass transfer between reactants, means are provided on the surface of the support element which can be protrusions from the surface (column 1, lines 55-57), the provision of a foraminated, cribriform or gauze-like porous plate (column 2, lines 9-18).
3. Claims 1 and 3 are novel over US-A-4 549 998 because they require the mesh or foam, respectively, to be provided as a layer on the surface whereas the structure according to US-A-4 549 998 does not have a separate surface. Claim 2 is also novel because the pins or wires mentioned therein are not unambiguously disclosed in US-A-4 549 998 which more generally refers to protrusions from the surface.
4. However, it appears that this does not result in a significant functional difference. The problems underlying the invention and US-A-4 549 998 are basically the same, and the solutions suggested in US-A-4 549 998 would guide the ordinarily skilled worker to the subject-matter defined in any of the independent claims 1, 2 or 3 by routine work, according to the circumstances, and he would obtain the claimed reactors without the exercise of an inventive skill. Consequently, the claimed reactors lack an inventive step.

It is not apparent that the features defined in the dependent claims contribute to an inventive step. It rather appears that they also are the result of routine work which the ordinarily skilled worker would carry out.



These publications therefore disclose the use of spinning disc technology for heating and mass transfer in inert and reactive systems.

5 GB 9903474.6 (University of Newcastle), from which the present application claims priority and the disclosure of which is hereby incorporated into the present application by reference, describes the use of RSORT in the conversion of a fluid phase substrate by dynamic heterogeneous contact with an agent. In this application, it is described how it has surprisingly been found that spinning disc technology may be further adapted to apply process intensification methods not only within the fields of heat and mass transfer but also within the field of heterogeneous contacting. Furthermore, it is described how it has surprisingly been found that the quality of the product obtained is of higher quality than that obtained by conventional processing having, for example, a higher purity or, in polymers, a narrower molecular distribution.

15 In addition to this, spinning disc technology can be used to obtain products not readily obtainable by other technology.

20 According to a first aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is provided with features which enhance its effective surface contact area in relation to the reactant.

25 According to a second aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is provided with a catalytic material.

30 The catalytic material may be applied as a smooth layer or may be roughened so as to provide enhanced surface area. Preferably, the catalytic material is a heterogeneous catalyst. Examples of such catalysts include platinum, palladium, nickel or any of these metals supported on or impregnated in a layer of alumina (for hydrogenation of liquids), or chromia (for polyolefin production).

35

According to a third aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is treated by ion bombardment or implantation so as to produce changes in surface wettability.

It is to be understood that the term "reactant" is not limited to substances which are intended to undergo chemical reaction on the surface of the support element, but also includes substances which are intended to undergo physical or other processes such as mixing or heating. Similarly, the term "product" is intended to denote the substance or substances which are collected from the first surface of the support element, whether these have undergone chemical or physical processing or both. In addition, although it is envisaged that most reactants and products will be in the liquid phase, the apparatus can be used with any suitable fluid phase reactants and products, including combinations of liquid, solid and gaseous reactants and products. For example, solid phase substances in substantially free-flowing particulate form can have macroscopic fluid flow properties.

Reference herein to a rotating surface is to any continuous or discrete planar or three dimensional surface or assembly which rotates approximately or truly about an axis, and preferably is reference to an approximate or true rotating surface of revolution. An approximate rotating surface of revolution may comprise an asymmetric axis and/or deviation in the surface body and/or circumference creating an axially or radially undulating surface of revolution. A discrete surface may be in the form of a mesh, grid, corrugated surface and the like.

Reference herein to a substantially radially outward flowing film as hereinbefore defined is to any fluid film which may be created by dynamic contact of the fluid phase reactant and the rotating surface as hereinbefore defined, suitably the fluid phase reactant is contacted with the rotating surface at any one or more surface locations and caused to flow outwardly by the action of centrifugal force. A film may be a continuous annulus or may be a non-continuous arc at any radial location. The substrate may provide a plurality of films in dynamic contact with a rotating surface as hereinbefore defined.

For example processes requiring extended contact time may be carried out in continuous manner with use of a recycle of fluid exiting at the periphery of the

**CLAIMS:**

1. A reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is provided with features which enhance its effective surface contact area in relation to the reactant.
2. A reactor as claimed in claim 1, wherein the surface is provided with at least one layer of a mesh.
3. A reactor as claimed in claim 2, wherein the surface is provided with two or more layers of a mesh.
4. A reactor as claimed in claim 2 or 3, wherein the layer or layers of mesh are such that there is good thermal conduction between the mesh and the surface.
5. A reactor as claimed in any one of claims 2 to 4, wherein the mesh is made of metal.
6. A reactor as claimed in any one of claims 2 to 5, wherein the mesh has a thickness of the same order of magnitude as a thickness of a film of reactant which is formed on the surface when the reactor is in operation.
7. A reactor as claimed in any one of claims 2 to 6, wherein the mesh is made out of or coated with a catalytic material.
8. A reactor as claimed in claim 1, wherein the surface is provided with at least one surface feature selected from the group including: reticulate foam, pellets, cloth, pins, wires, grooves.
9. A reactor as claimed in claim 1, wherein the surface is porous.
10. A reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is provided with a catalytic material.

11. A reactor as claimed in claim 10, wherein a plate of catalytic material is clamped, welded or otherwise adhered to the surface.
- 5 12. A reactor apparatus including a support element adapted to be rotatable about an axis, the support element having a surface and feed means associated therewith for supplying at least one reactant to the surface, characterised in that the surface is treated by ion bombardment or implantation so as to produce changes in surface wettability.
- 10 13. A reactor as claimed in any preceding claim, wherein the axis is substantially parallel to a direction of action of terrestrial gravity.
14. A reactor as claimed in any one of claims 1 to 12, wherein the axis is inclined with respect to a direction of action of terrestrial gravity.
- 15 15. A reactor as claimed in any one of claims 1 to 12, wherein the axis is substantially perpendicular to a direction of action of terrestrial gravity.
- 20 16. A reactor as claimed in any preceding claim, wherein there is further provided a rotary impeller or fan mounted close to the first surface and operable to generate a gaseous flow from a periphery of the surface towards a central region thereof, this flow being counter-current to a flow of reactant on the first surface.
- 25 17. A process for the conversion of a substantially fluid phase substrate by heterogeneous contact of the substrate or a fragment or derivative thereof with a substantially solid phase agent wherein the solid phase agent is comprised as a surface of a support element or part thereof and the support element is adapted to rotate around an axis such that the solid phase agent provides a rotating surface or part thereof and the substrate provides a film flowing substantially radially outward
- 30 from the axis in dynamic contact with the agent.

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>CTV/P45136W0</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 00/ 00519</b>	International filing date (day/month/year) <b>17/02/2000</b>	(Earliest) Priority Date (day/month/year) <b>17/02/1999</b>
Applicant <b>UNIVERSITY OF NEWCASTLE et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.  
☒ It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of Invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☒ because this figure better characterizes the invention.

4  
☐ None of the figures.

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7 B01J19/18 C08F2/01 B01J19/12

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01J C08F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 549 998 A (PORTER JOHN E, RAMSHAW COLIN) 29 October 1985 (1985-10-29)  column 2, line 9 - line 60 column 2, line 67 - column 3, line 45 claims 1-6; figures 1-3	1,2,5,6, 8,9,12, 13
X	EP 0 499 362 A (TIOXIDE GROUP SERVICES LTD) 19 August 1992 (1992-08-19) cited in the application the whole document	1,8-13, 15,17
X	US 4 311 570 A (COWEN GEOFFREY, NORTON-BERRY PHILIP, STEEL MARGARET L) 19 January 1982 (1982-01-19) column 7, line 1 - line 41 column 9, line 62 - column 10, line 9  -/-	1,9-11, 16,17

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&amp;" document member of the same patent family

Date of the actual completion of the international search

2 August 2000

Date of mailing of the international search report

09/08/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Vlassis, M

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 627 803 A (UMETSU JUNICHI) 9 December 1986 (1986-12-09) the whole document ----	10
A	EP 0 020 055 A (ICI PLC) 10 December 1980 (1980-12-10) page 6, line 1 -page 15, line 38 figure 1 -----	1,2,5,8, 9,12-15

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/63 00/00519

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4549998 A	29-10-1985	DE 3268599 D EP 0080311 A JP 5018618 B JP 58104623 A	27-02-1986 01-06-1983 12-03-1993 22-06-1983
EP 0499362 A	19-08-1992	AU 646133 B AU 1037992 A CA 2059932 A DE 69203877 D DE 69203877 T DK 499362 T ES 2075602 T GB 2252707 A,B US 5308458 A	10-02-1994 13-08-1992 10-08-1992 14-09-1995 07-12-1995 18-09-1995 01-10-1995 12-08-1992 03-05-1994
US 4311570 A	19-01-1982	AU 530811 B AU 4446879 A AU 4446979 A CA 1125994 A DE 2965174 D DE 2967553 D EP 0003906 A EP 0003907 A EP 0056001 A IT 1111205 B IT 1111204 B JP 1437023 C JP 54126675 A JP 62043735 B JP 54126676 A NZ 189726 A NZ 189727 A	28-07-1983 30-08-1979 30-08-1979 22-06-1982 19-05-1983 23-01-1986 05-09-1979 05-09-1979 14-07-1982 13-01-1986 13-01-1986 25-04-1988 02-10-1979 16-09-1987 02-10-1979 29-05-1981 29-05-1981
US 4627803 A	09-12-1986	DE 3481062 D EP 0138355 A US 4675137 A	22-02-1990 24-04-1985 23-06-1987
EP 0020055 A	10-12-1980	AR 225923 A AT 24118 T AU 530583 B AU 5879880 A BR 8003373 A CA 1157632 A DE 3071856 D DK 235180 A,B, ES 492020 D ES 8102839 A JP 1506916 C JP 56026502 A JP 63052921 B KR 8301017 A MX 153367 A NO 801534 A,B, PL 224626 A RO 86504 A SU 1828406 A ZA 8003061 A	14-05-1982 15-12-1986 21-07-1983 04-12-1980 30-12-1980 29-11-1983 22-01-1987 01-12-1980 16-02-1981 16-05-1981 13-07-1989 14-03-1981 20-10-1988 25-05-1983 03-10-1986 01-12-1980 13-02-1981 15-03-1985 15-07-1993 27-05-1981